

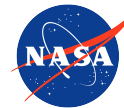


Do You See What I See? Interactive Visualization of Mission Design and Navigation (MDNav)

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05-Oct.-2018

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Why Interactive Visualization?

Data & Scripts



Analysis Engine



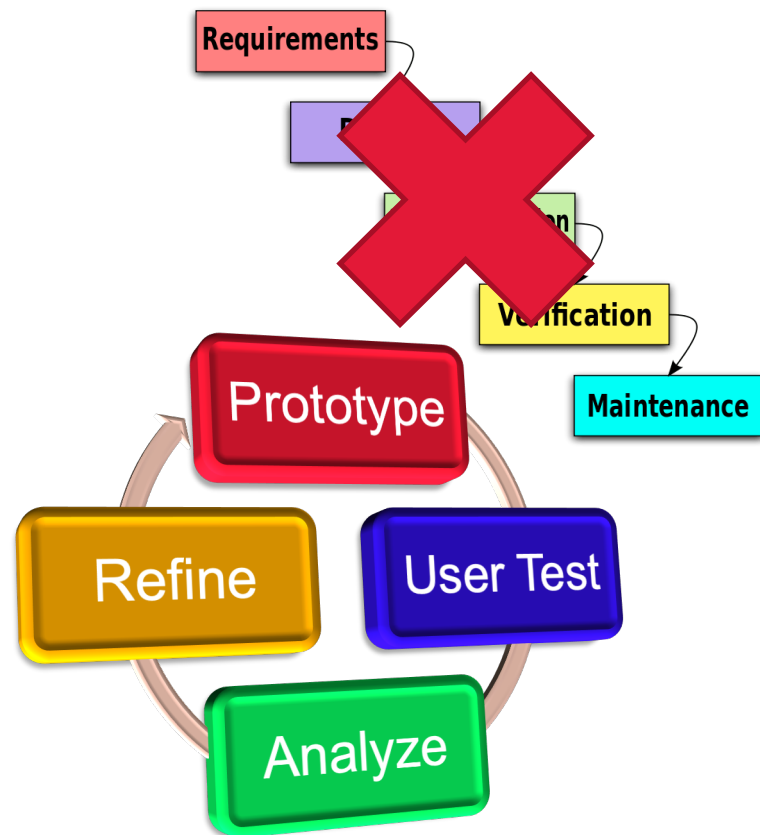
Visualization



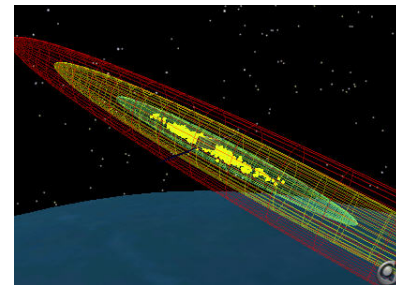
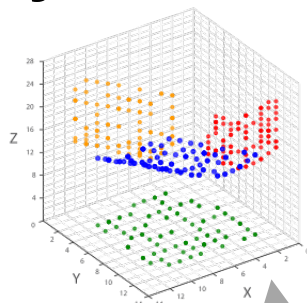
Interactive Visualization & Human-Centered Design



Picking & Linking Visualizations

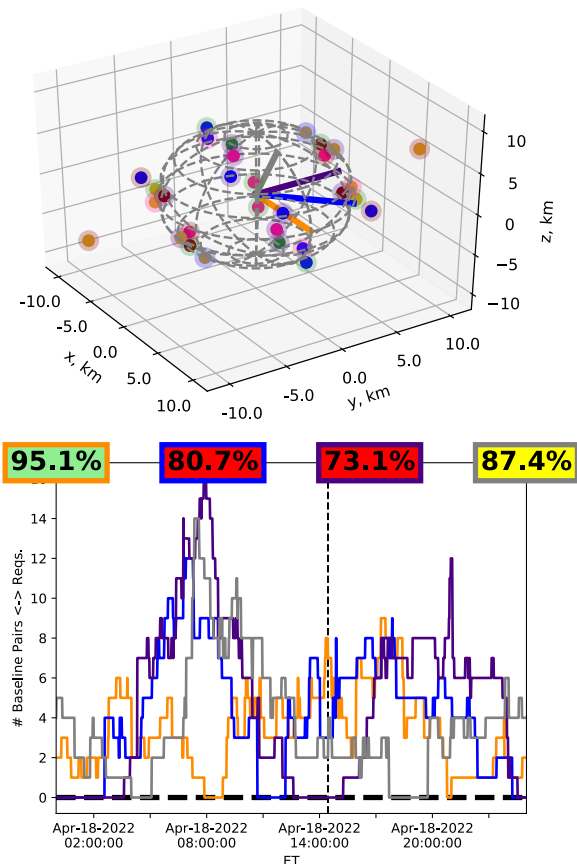
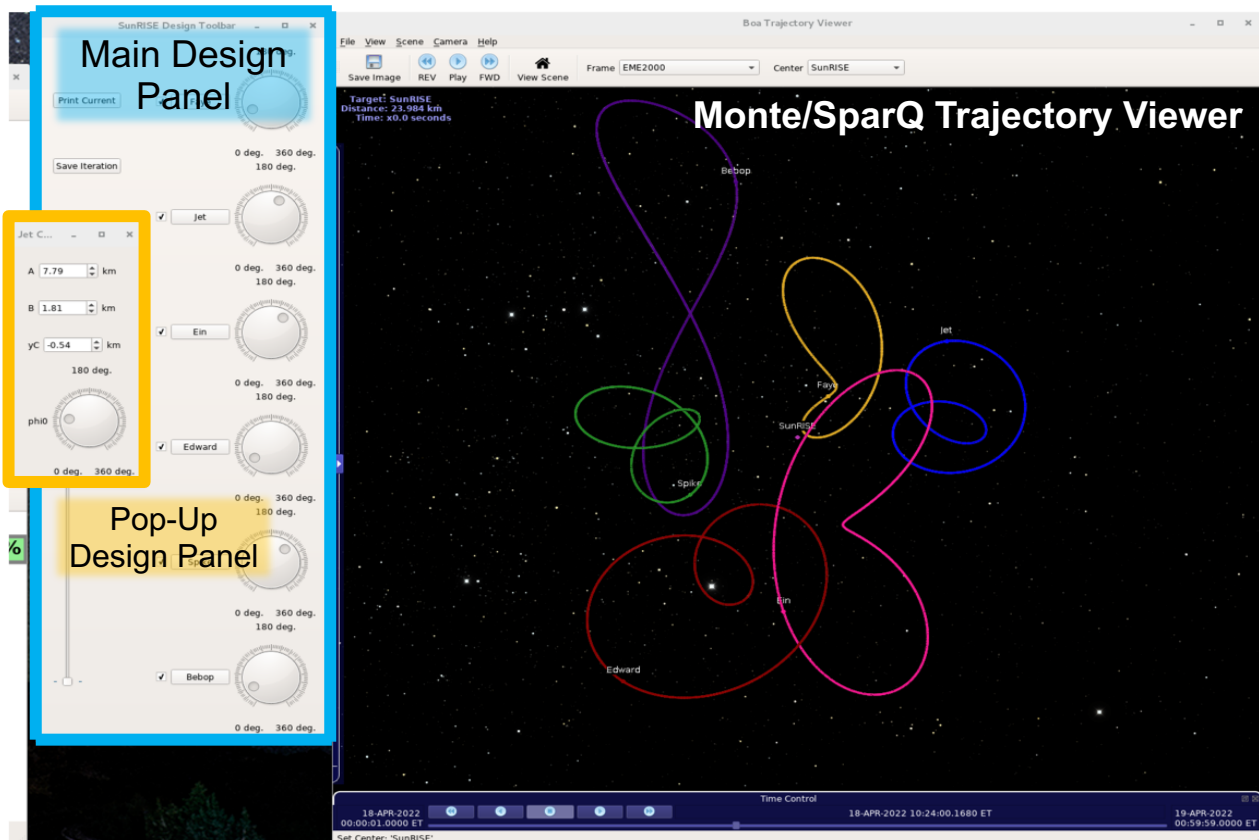


Mission Life Cycle & Analysis Needs

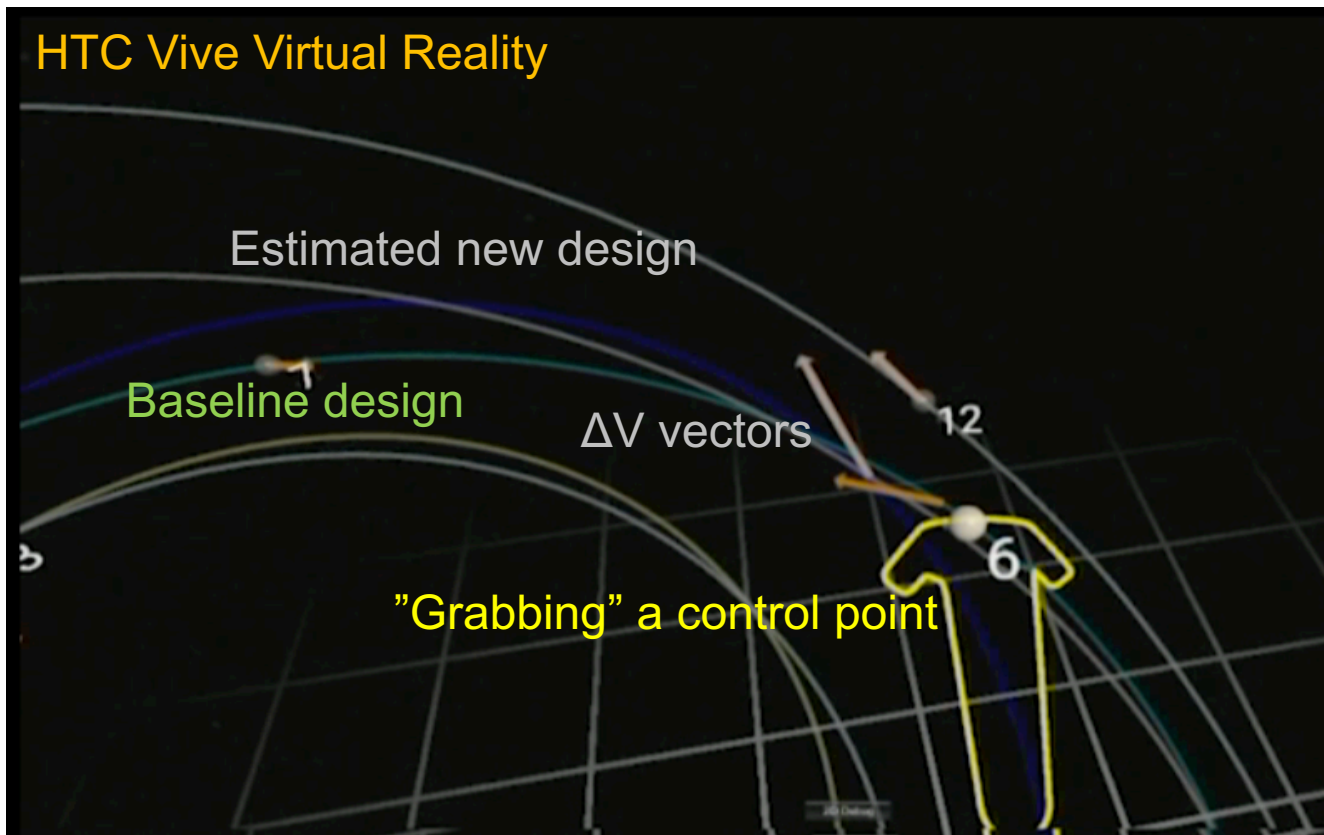


Interactive Visualization Needs	Mission phases						
	Concept Formulation (Phases Pre-A-B)		Implementation (Phases C-D)		Operations (Phases E-F)		
	Guess & Check	Broad Search	Targeting & Optimization	Statistical Analyses	Orbit Determination	Maneuver Planning	Sequencing & Verification
Trajectory Viewer	✓	~	✓	~	~	~	✓
Inputs & Models	~	✓	~	✓	✓	~	~
Timeline Viewer	~	~	✓	~	✓	✓	✓
Astrodynamic Plots	✓	~	~	~	✓	✓	✓
Data Clouds		✓		✓	~	~	
Constraints	✓	~	✓		~	~	~
Iterations	✓		✓		✓	✓	
Raw Images					✓		~

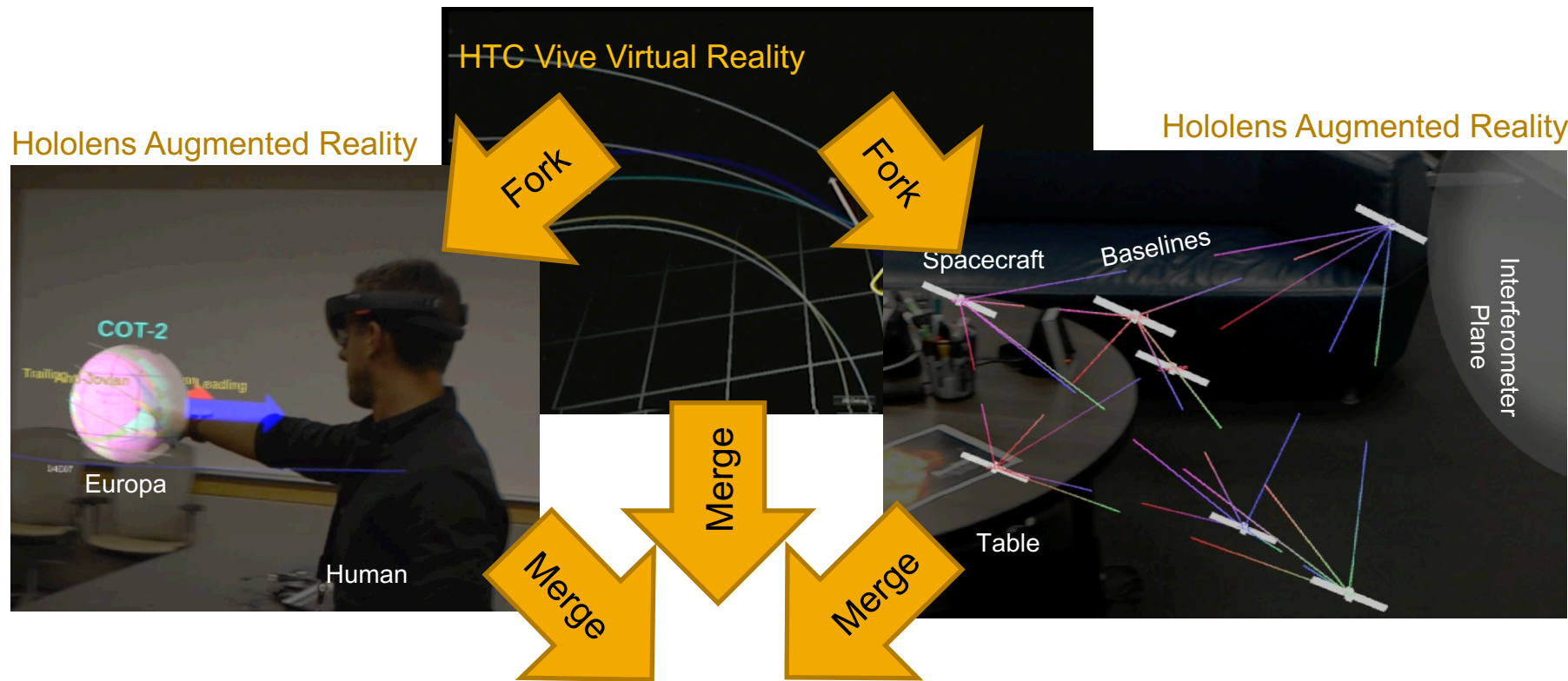
Guess & Check – Rapid Formation Design



Guess & Check – Rapid Trajectory Design



Human-Centered Iteration – Rapid Trajectory Design



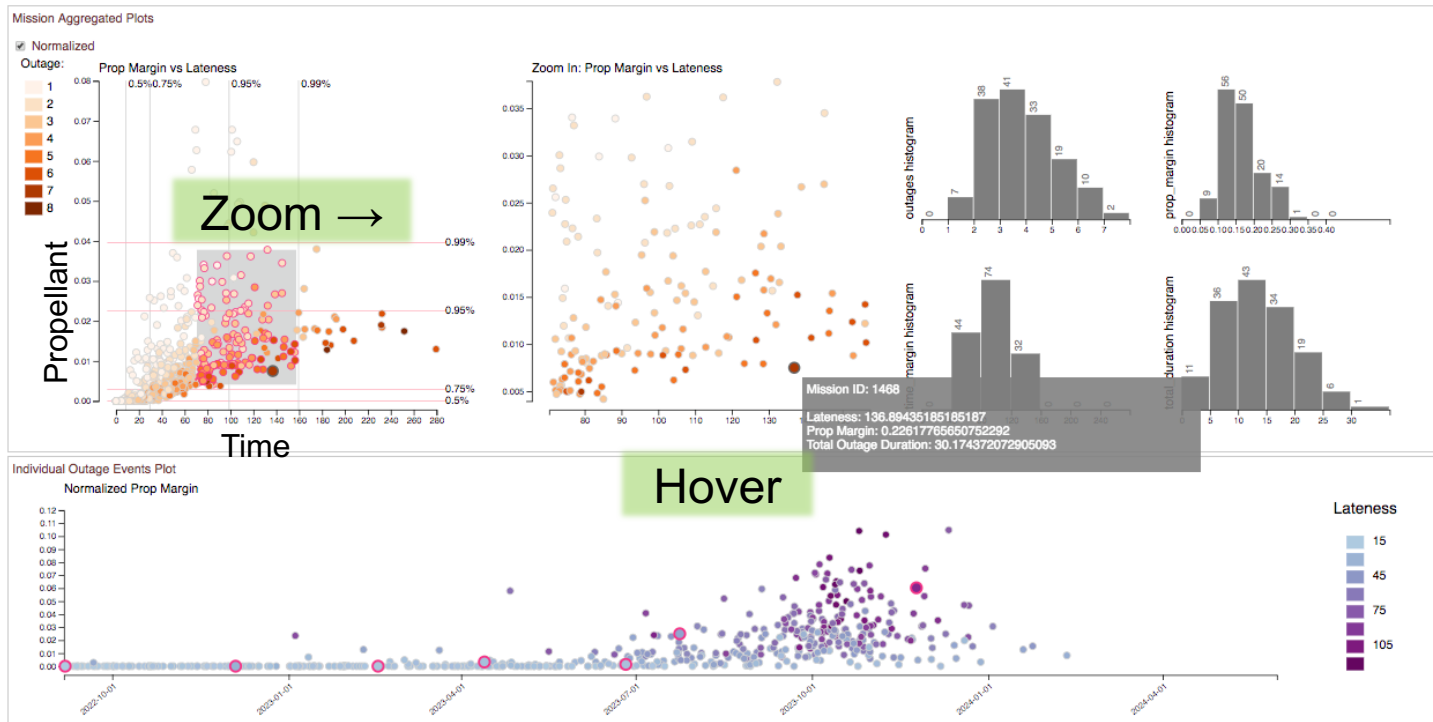
Statistical Analysis – Missed Thrust Monte Carlo



MonteCarlo Visualization

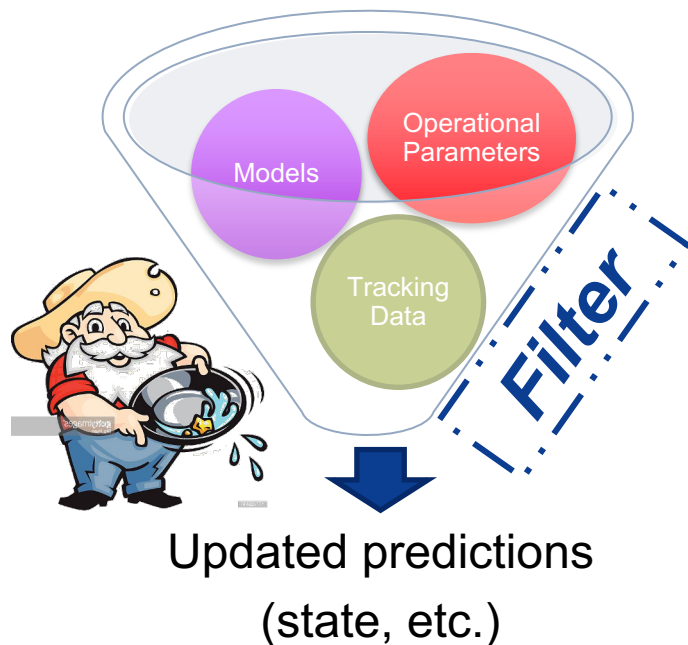
Select Input:

NEXT 4K



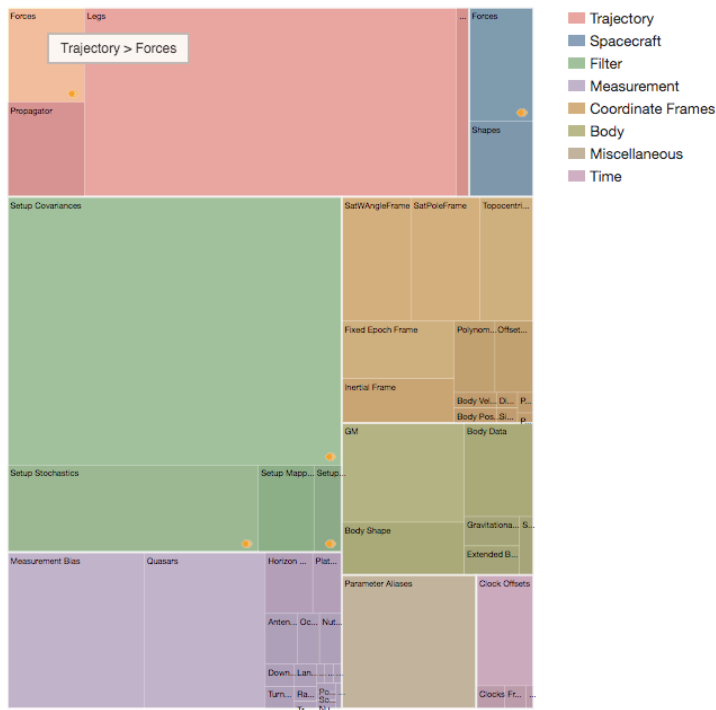
Orbit Determination – Dashboard (OD-D)

Orbit Determination



Input BOA Comparison

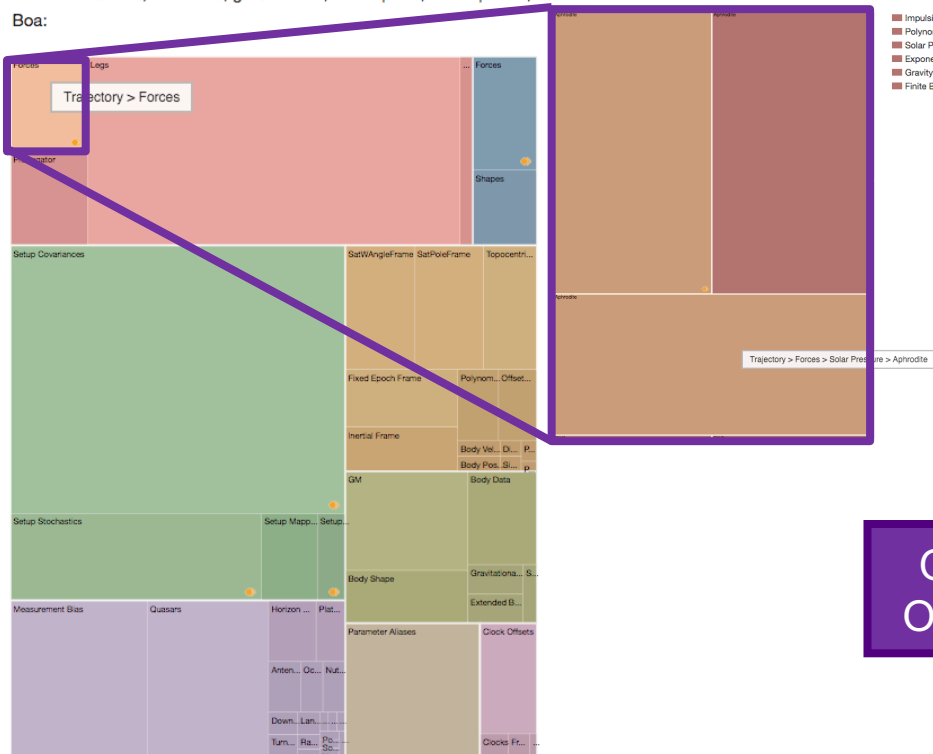
7 cases: baseline, dataEdits, gmConsider, mnvrApriori, mnvrApriori2, noSFFstochs, tightState
Boa:



Orbit Determination – Dashboard (OD-D)

Input BOA Comparison

7 cases: baseline, dataEdits, gmConsider, mnvrApriori, mnvrApriori2, noSFFstochs, tightState
Boa:



Input BOA Comparison

7 cases: baseline, dataEdits, gmConsider, mnvrApriori, mnvrApriori2, noSFFstochs, tightState
Boa: / Trajectory / Forces / Impulsive Burns

Aphrodite

Body:
Aphrodite

DeltaVel:

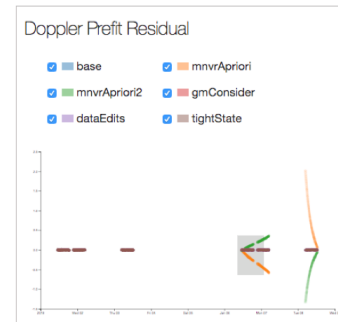
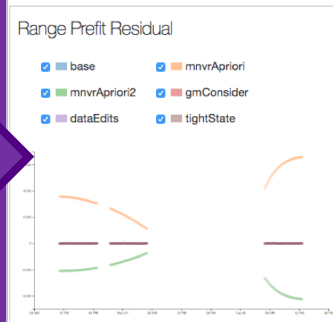
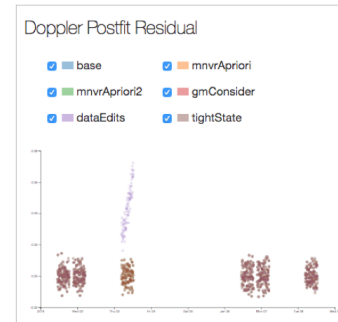
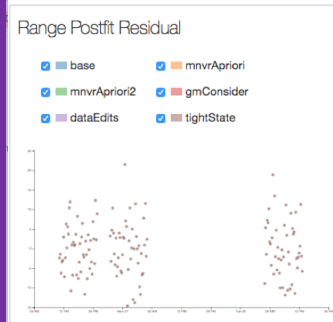
baseline	mnvrApriori	mnvrApriori2
0.00000000	1.00000000	-1.00000000
0.00000000	-2.00000000	1.00000000
1.00000000	1.00000000	1.00000000

changed:
primitive change - m

Name:
OTM-1

Frame:
EMO2000

Query
Outputs



Summary & Future Work

MDNav + Interactive Visualization + Human-Centered Design

- Reduce time to discovery
- Encourage low-risk exploration
- Rapid prototyping & user feedback
- Generalized libraries, focused "apps"

Future Work

- Continued iteration on prototypes
- Expand to other MDNav tasks
- APIs & Libraries → Customized Mission Environments



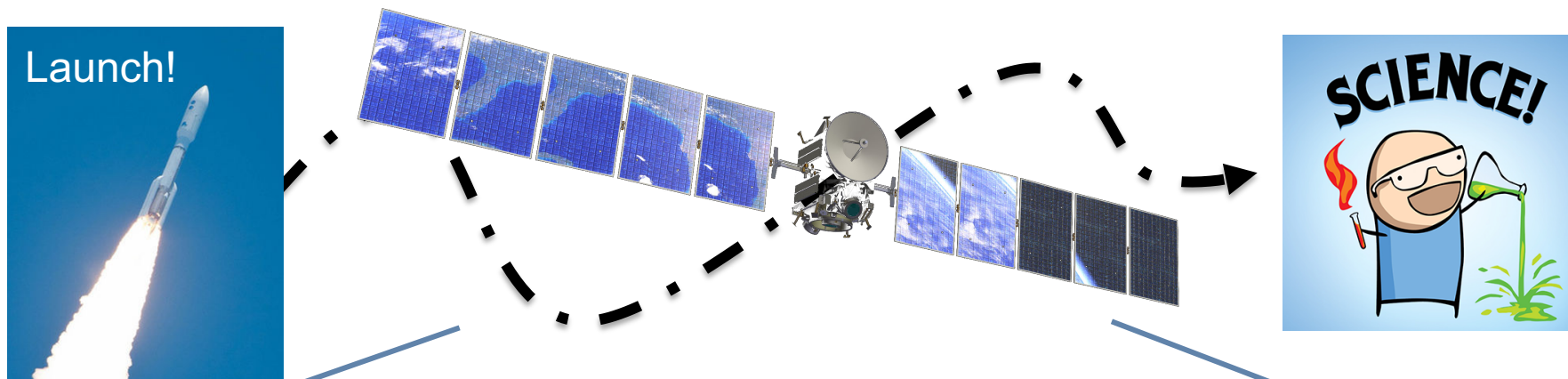


Jet Propulsion Laboratory
California Institute of Technology

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Mission Design & Navigation

How to get where you're going when where you're going is always moving



Mission Design: Where you want the spacecraft to go

Navigation: What you do to get the spacecraft there

Current Astrodynamics Tools

